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Effect of Gagne's Learning Hierarchy and Sex on Students' Achievement, Retention and Attitude towards Physics

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Abstract: *The study verified the effects of Gagne's learning hierarchy and sex on students' achievement, retention, and attitude in Senior School Physics in Delta State. The theoretical framework on which the study was anchored is Ausubel's Cognitive Theory. The study employed a non-equivalent pre-test post-test quasi-experimental design. Three (3) research null hypotheses were tested at 0.05 level of significance. A sample size of one hundred and sixteen (116) SS II physics students from three (3) public senior secondary schools in Delta State was involved. They were taught physics concepts using Gagne's Learning Hierarchy in the experimental groups consisted of one hundred and sixteen (116) students. The instruments used were Physics Achievement Test (PAT) and Physics Students Attitude Questionnaires (PSAQ). The instruments were validated by experts in physics and science education, with reliability indices of 0.79 for PAT and 0.73 for PSAQ. The data retrieved were analyzed using Mean, Standard Deviation, and Independent t-test. The findings revealed that Gagne's Learning Hierarchy was unbiased concerning physics students' achievement, retention, and attitude regarding their sex. Assertively, the study stated that using Gagne's Learning Hierarchy in teaching senior school physics is appropriate; due to the unbiased learning opportunity it offered the physics learners.*

Keywords: *Gagne's Learning Hierarchy, Strategy, Sex, Male, Female, Achievement, Retention and Attitude.*

Introduction

Background to the Study

Fundamentally, Physics is the natural science subject that deals with the properties of matter and its interaction with energy and force. It is typically an experimental subject. Values and thoughts bring forth from physics are very helpful in understanding of natural events. The concentration of physics instructions is to usher students to the knowing of physics values and to have the cognition to utilize this knowledge. It is a field specifically obsessed with two basic aims, the presentation of a scientifically sophisticated society and the improvement of latent scientific and technological workforce (Ogunniyi, 2001).

Consequently, the National Policy on Education (FRN, 2004, 2007, 2013) expressed explicitly in the secondary school physics curriculum its objectives as:

(i) provide basic literacy of physics for functional living in the society,

(ii) acquire basic conceptions and values of physics as a provision for promoting studies,

(iii) get indispensable technological ability and cognition as a provision for the technical utilization of physics, and

(iv) excite and heighten creativeness.

Physics as a fundamental science deals with the matter and energy in nature. Many students perceive physics to be difficult despite different interventions, such as the introduction of new Educational Systems. Literature (Barmby and Defty, 2006; Lavonen, Meisano, Byman, Uiito and Juiit, 2005; Angell, Guttersrud, Henriksen and Isnes, 2004; Williams, Stanisstreet, Spall, Boyes and Dickson, 2003) opined that students specifically distinguish against physics as conceptually challenging, intangible, and boring that only extraordinary exceptional students' acknowledge and endure its teaching and learning. Nevertheless, educators steadfastly accept that students acquire high-grade and accomplish in physics if they discover the instruction understandable (Gebbels, Evans and Murphy, 2010). Additionally, these writers asserted that students' conceptualization of physics determines their knowing and acquisition of the course of study.

Gagne's Learning Hierarchy gives teachers a procedure required to be utilized earlier to prosecute instruction. Every measure, details a kind of information which supports the acquisition procedure. At the completion of a particular phase, the students' participation will be achieved and the retention of communicated details or abilities which they are being taught. These steps are (i) gaining attention (ii) informing learners of objectives (iii) stimulating recall of prior knowledge (iv) presenting the stimulus (v) providing learning guidance (vi) eliciting performance (vii) providing feedback (viii) assessing performance (ix) enhancing retention and transfer.

Gagne's learning hierarchy has the major advantage for students to problem-solving skills and enhances retention as well as application of physics concepts. Simha (2000) stated that studies conducted using Gagne's learning hierarchy compared to the traditional lecture method shows that there is superiority of Gagne's learning hierarchy over the traditional lecture method. This was evidently noticed in it's positive impact in the areas of achievement, retention and attitude application of principles and problem-solving skills in physics.

Sex is the state of being male or female (Okebukola, 2002). Therefore, the study also investigated whether the achievement, retention and attitude of physics students' that were exposed to the two instructional strategies under study depend on sex. Researchers (Aguele and Agwugah, 2008; Kolawole, 2007; Bamidele, Odusola and Dibu – Oyerinde, 2006; and Okebukola (2002)

discovered in respect of the male learners accomplish, importantly, better than their female counterparts in physics. Also, Amoo (2011), Umar (2008) and Christine (2004) in their studies were of a different view that the performances of female students in science subjects were better than that of the male counterparts. In another conflicting view also, generally in Nigeria if not Africa as a whole, it is a belief that male students are at the forefront when compared to their female counterparts in physics (Adigun, Onihunwa, Irunokhai, Sada and Adesina, 2015). The comparative achievement of male and female students' in senior school physics is contradictory. This implies that an important deviation among the achievement scores of boy versus girl physics students have not been conclusively reached by researchers. Therefore, a research of this quality is necessitated.

Students' achievement, according to Hattie (2009), means a resultant effect of instruction and acquisition where certain aims concerning the subject matter is realized, specific aims in respect of focusing on activeness concerning an educational situation, specifically in educational institutions. Students' achievement is the outcome of learning which expresses the degree of instructional objectives that have been met. Anene (2005) defined students' accomplishment as achievement in an educational institution's subject matter acquisition which is usually expressed in grade or mark obtained in a standard test. The intervention package of Gagne's Learning Hierarchy have shown in definite studies to significantly improve students' achievement, retention and attitude in different subject areas including physics (Kim, 2016; Fortus, Sutherland, Adams, Krajcik and Reiser, 2015; Pes, man and Ozdemir 2012; Guido and De la Cruz 2012; Erdemir, 2009; Simha, 2000). Instructional Conversation and Gagne's Learning Hierarchy utilization did not only advance achievement and retention, but also improved students' attitude.

Chinanson, Kurumeh and Obida (2010) while elaborating on the works of Kunbo and Tutoo (2002) explicated that students' retention is the preservative factor of the mind. They asserted that the mind acquires materials of knowledge and information through sensation and perception. When a stimulating situation occurs, retained images are revived or reproduced to make assimilation possible. In this light, when teaching physics concepts there is need for concepts to be given to the pupils in ways that awaken their sub-conscious which can initiate speedy inclination of the ideas being learned or taught. Gagne's Learning Hierarchy is an effective instructional strategy that can serve this purpose of actually making both fast and slow learners understand and retain physics concepts through their collaborative and active learning processes.

Akinsola and Olowojaiye (2008) defined attitude as "psychological constructs theorized to be composed of emotional, cognitive and behavioural components". They further stated that impressive educational approaches will assert affirmative cognition in the learners concerning educational institution's course of study. It is generally believed that students' attitude towards physics determines their success in physics. Attitude is the inclination to deliberate consciousness and respond affirmatively or antagonistically concerning a target in our environment. They further stressed that attitude organizes thoughts, emotions and behaviours towards a psychological object. In the context of this study, attitude is the feeling of the students' towards learning physics. This feeling can be affected positively or negatively by the instructional strategy adopted by the physics teachers. The use of interactive, collaborative and student-centred instructional strategies including Gagne's Learning Hierarchy is capable of creating students positive attitude toward learning physics, thereby encouraging high achievement and retention in physics.

Statement of the Problem

Consequently, the controversies among science education researchers with respect to Sex and students' achievement, retention and attitude in science subjects calls for further attention, hence this research was prompted. Therefore, this study on the "Effect of Gagne's Learning Hierarchy and Sex on Students achievement, retention and attitude towards Senior School Physics in Delta State, Nigeria was carried out. Accordingly, the problem of this study is: Is there any effect of Gagne's Learning Hierarchy on students' sex and their Achievement, Retention and Attitude in Senior School Physics?

Specific objectives of the study

Specifically, this research was designed to reveal:

i. If there is any difference in the mean achievement scores of male and female physics students that were exposed to Gagne's Learning Hierarchy.
ii. If there is any difference in the mean retention scores of male and female physics students that were exposed to Gagne's Learning Hierarchy.
iii. If there is any difference in the mean attitude scores of male and female students that were exposed to Gagne's Learning Hierarchy.

Research Questions

The following research questions have been raised to pilot this investigation.

i. What is the difference in the mean achievement scores of male and female physics students that were exposed to Gagne's Learning Hierarchy?
ii. What is the difference in the mean retention scores of male and female physics students that were exposed to Gagne's Learning Hierarchy?
iii. What is the difference in the mean attitude scores of male and female physics students' that were exposed to Gagne's Learning Hierarchy?

Hypotheses

The following null hypotheses were tested at 0.05 level of significance.

i. There is no significant difference in mean achievement scores of male and female physics students exposed to Gagne's Learning Hierarchy.

ii. There is no significant difference in mean retention scores of male and female physics students exposed to Gagne's Learning Hierarchy.

iii. There is no significant difference in mean attitude scores of male and female physics students exposed to Gagne's Learning Hierarchy.

Methodology

The design of the study is a non-equivalent pre-test; post-test quasi-experimental design. It examines the effect of Gagne's learning hierarchy and sex on the dependent variables. The study involved three experimental groups only, consisting of both male and female senior school physics students. A pre-test was administered to the groups, before the treatment and ensured the groups 'comparative effects of male and female in the experimental groups on achievement, retention and attitude in senior school physics. The experimental groups were taught physics concepts utilizing Gagne's learning hierarchy. A posttest was administered to the groups after the treatment period of six (6) weeks to establish the effect of the treatment on the dependent variables.

Population and Sampling Technique

This study's population involved four hundred and thirty five (435) Public Senior Secondary Schools in Delta State. The study utilized one hundred and sixteen (116) SS II Physics Students from three (3) public senior schools that were randomly selected. The study utilized three (3) SS II physics whole classes of senior school II students from the three (3) designated schools. Simple random sampling technique was equally applied at every stage of selection. At the first stage, a simple random sampling was applied to designate one Local Government Area from each senatorial district. Secondly, simple random sampling was utilized to designate one (1) senior school from each of the Local Government Areas designated. Thirdly, designated senior school IIA (SS IIA) class as the intact (whole) class among the designated schools, and were assigned as the experimental groups through "hat and draw" method. This method was randomly applied and eradicated any form of bias in the selection

Validity and Reliability

The study utilized two (2) research instruments including Physics Achievement Test (PAT) and Physics Students Attitude Questionnaires (PSAQ). The Instruments were validated through face validity, content validity and construct validity. Reliability Indices of 0.79 for PAT and 0.73 for PSAQ were obtained through Kuder-Richardson formula 21 and Cronbach-Alpha formula respectively.

Treatment Procedure

I. Training of Research Assistants for Experimental Group

Three Physics teachers used as Research Assistants were trained on the techniques of using Gagne's Learning Hierarchy. This lasted for five days. Day one involved the researcher to request for the approval from the designated schools Principals to allow their physics instructors and pupils to participate in the study. On the second day, the researcher exposed to the three physics instructors to the theories, origin and features of Gagne's Learning Hierarchy. On the third day, the teachers were trained using the training manuals prepared by the researcher on Gagne's Learning Hierarchy. The fourth day was spent on practice and generation of ideas regarding application of Gagne's Learning Hierarchy in instructing Physics concepts. The trained Research Assistants were evaluated and were seen to have accurate understanding on how to apply Gagne's Learning Hierarchy in instructing physics contents.

II. The Step by Step Treatment Procedure

Gagne's Learning Hierarchy is the strategy applied as treatment. The treatment lasted for six weeks. A week before the start of treatment the researcher distributed the instructional units to the six research assistants. The instructional units contained Physics contents which includes: (i) Linear Momentum I (ii) Linear Momentum II (iii) Mechanical Energy I (iv) Mechanical Energy II (v) Heat Energy I Temperature and its Measurements and (vi) Heat Energy II Temperature and its Measurements as contained in Delta State Senior School Physics SS II plan of action. Intervention materials which were circulated earlier were based on these two reasons: (i) to familiarize research assistants with contents of the lessons and (ii) to ensure unbiased instructional presentation by following the endorsed format for the designated classes. Two days before the start of treatment, the experimental groups were pretested with the 40 items of the Physics Achievement Test (PAT) and 30 statements of the Physics Students Attitude Questionnaires (PSAQ). This was done for the groups before treatment, so that any noticed change should be as a result of the applied treatment.

Gagne's Learning Hierarchy

Gagne's theory is better aligned with both theory of teaching plus acquisition theory (Gagne, 1985). In accordance with Robert Gagne, nine events of instruction are obtainable which are also referred to as "Gagne's Learning Hierarchy" that is necessary to create conditions for learning includes:

1. gaining attention;
2. informing learners of the objectives;
3. stimulating recall of prior learning;
4. presenting the stimulus;
5. providing learning guidance;
6. eliciting performance;
7. providing feedback;
8. assessing performance and
9. enhancing retention and transfer.

1. **Gaining Attention:** This event ensured that the physics students are effectively involved in respect of acquisition procedure.
2. **Inform Pupils of the Objectives.** This activity provides physics students with the opportunity to be aware of their expected learning outcomes in every physics lesson**.**
3. **Stimulating Recall of Prior Learning.** This activity provides physics students the opportunity to link their prior knowledge to new content and facilitate effective learning process in senior school physics.
4. **Presenting the Stimulus Material.** This event involves the display of new contents by the physics teacher to the physics learners with respect to learning the new content progresses from simple to complex.
5. **Providing Learning Guidance.** This event ensured that the physics teacher provides further guidance that generated an interactive and meaningful physics learning environment to facilitate effective physics learning.
6. **Eliciting Performance.** This event (activity) enables the physics teacher to establish what the physics students have achieved.
7. **Providing Learning Feedback.** This event ensures that the physics teacher provides correct response to physics students' perceptive with respect to new subject matter acquisition.
8. **Assessing Performance.** This activity gave physics students the opportunity to receive test in respect of the new content learned to find out their level of achievement.
9. **Enhancing Possession as well as Association.** This event provides the physics students' opportunity to keep on new content learned and transfer same to related acquired cognition.

Gagne's theory provides priceless subject matter details to instructors. Applying Gagne's Learning Hierarchy with respect instruction provides pleasing style in ensuring impressive plus organized acquisition of physics lesson by providing composition for the instruction design with complete perspective in instructing and learning.

The students were tested during the next lesson's period after the treatment with 40 items of the Physics Achievement Test (PAT) and 30 statements of the Physics Students Achievement Questionnaires (PSAQ) after reshuffling the items. Similarly a delayed posttest was administered on the physics students four (4) weeks after treatments for retention.

Data Analysis

The data retrieved from the administered Physics Achievement Test (PAT) and Physics Students Attitude Questionnaires (PSAQ) were analyzed utilizing mean, standard deviation and independent sample t-test. The significant level to which a hypothesis is rejected or not rejected is at 0.05.

Analyses and Results

HO_1.

There is no significant difference between the mean achievement scores of male and female students that were exposed to Gagne's learning hierarchy.

Table 1

Independent t –test on the Mean Achievement Scores of Male and Female Physics Students' that were exposed to Gagne's Learning Hierarchy Strategy

Sex	N	Mean	mean diff.	SD	t	df	sig (2-tailed)
Male	50	68.44		12.88			
			-0.56		0.24	114	0.81
Female	66	69.00		12.50			

P > 0.05

Table 1 showed that in the posttest, the t-value of 0.24 and p-value of 0.81. Testing the null hypothesis at an alpha level of 0.05, the p-value of 0.81 was higher compared the alpha level of 0.05. Therefore in the posttest the null hypothesis failed rejection. Which implied no significant difference existed between the mean achievement scores of male and female physics students' exposed to Gagne's Learning Hierarchy.

Hypothesis 2: There is no significant difference between the mean retention scores of male and female physics students that were exposed to Gagne's Learning Hierarchy Strategy.

Table 2

Independent t-test on the Mean Retention Scores of Male and Female Physics Students that were exposed to Gagne's Learning Hierarchy strategy

Sex	N	Mean	Mean diff.	SD	t	df	Sig (2tailed)
Male	50	59.00		11.99			
			0.18		0.08	114	0.93
Female	66	58.82		11.20			

P > 0.05

This outcome concerning table 22, shows that t-value of 0.08 and p-value of 0.93. Testing the null hypothesis at an alpha level of 0.05, the p-value of 0.93 is higher in comparison with the alpha level of 0.05. Therefore, the null hypothesis that states "There is no significant difference between the mean retention scores of male and female physics students that were exposed to Gagne's Learning Hierarchy Strategy" was not rejected.

Hypothesis 3: There is no significant difference in mean attitude scores between the male and female physics students exposed to Gagne's learning hierarchy strategy.

Table 3

Independent t-test on the Mean Attitude Scores of Male and Female Physics Students that were exposed to Gagne's Learning Hierarchy Strategy

Sex	N	Mean	Mean diff.	SD	t	df	sig (2tailed)
Male	50	88.36		13.61			
		0.69		0.29	114	0.77	
Female	66	87.67		11.73			

P>0.05

This outcome regarding table 3 indicated the t-value of 0.29 and p-value of 0.77. Testing the null hypothesis at an alpha level of 0.05, the p-value of 0.77 is higher in comparison with alpha level of 0.05. Therefore, the null hypothesis failed rejection. This disclosed a situation of no significant difference between the mean attitude scores of male and female physics students that were taught Gagne's Learning Hierarchy Strategy.

Discussions

The outcome of this study regarding hypothesis (HO_1) indicated a situation of no significant difference concerning the posttest mean achievement scores of male and female physics students that were exposed to Gagne's learning hierarchy. The observed no substantial change in the mean achievement scores of male and female physics students revealed that students' achievement in physics is irrespective of sex while applying Gagne's Learning Hierarchy. One probable reason for this finding should be that Gagne's learning hierarchy strategy has provided male and female physics students' equal opportunity to participate effectively regarding instruction-acquisition situation and it has encouraged them in building self-confidence in solving physics problems and ensured effective achievement in physics as evident in this study. This discovery is in agreement with Ajai and Imoko (2015), who revealed that male and female pupils instructed in physics using problem-based strategy did not differ significantly in their achievement scores. This discovery agreed in line with of Ifamuyiwa and Ajilogba (2012), who noted a situation of non-significant difference between achievement scores of male and female pupils exposed to problem solving model strategy in science. However, this study's discovery disagrees with the result of Zembar and Blume (2011), arguing that girls rather than boys accomplish better-quality in learning. The outcome of this study is, also, in disparity with regarding Dayioglu and Turut-Asit (2004), where they reaffirmed that girls performed better than boys in science acquisition. The outcome of study with the application Gagne's Learning Hierarchy in instructing senior school physics has evident the non-bias nature of the treatment. This should ensure that Gagne's Learning Hierarchy as an instructional strategy has met the expectation and requirement of Science Education based on its non-bias nature concerning the learners' sex.

Outcome concerning hypothesis (HO_2) disclosed a situation of no significant quality regarding the average retention score of male plus female pupils instructed in physics using Gagne's learning hierarchy strategy. The observed no considerable difference in the mean retention scores of male and female physics students revealed that students' retention in physics is irrespective of sex with use of Gagne's learning hierarchy as an instructional strategy. One thinkable clarification to this discovery might be that Gagne's learning hierarchy has provided male and female physics students' equal opportunity to participate effectively regarding instruction-acquisition situation and it has encouraged them in building self-confidence in solving physics problems and ensured effective retention as evident in this study. The discovery equally conforms to Moore and Stanley (2010) who affirmed a situation of no significant difference between male and female pupils exposed to Gagne's learning hierarchy strategy and their retention in physics. The discovery of this current work opposed the view of Gillies, Nichols, Burgh and Haynes (2013) who find a significant difference regarding the mean retention scores of students exposed to Gagne's Learning Hierarchy strategy in support of the female students in science. This finding equally contradicts the views of Mercer and Dawes (2008) who reported that males in the experimental group (Gagne's Learning Hierarchy) significantly performed better than their female counterparts in science. Another probable reason for this non-significantly different outcome between male and female students in physics that were exposed to the treatment is as result of the effectiveness of the treatment in addressing gender learning challenges in senior school physics.

This outcome in hypothesis (HO_3) reaffirmed a situation of no significant difference in respect of the mean attitude scores of male and female pupils instructed senior school physics using Gagne's learning hierarchy strategy. The observed no considerable difference in the mean attitude scores of male and female physics students revealed that students' attitude in physics is irrespective of sex. Possible explanation to this discovery is that Gagne's learning hierarchy strategy has provided male and female physics students equal opportunity to participate effectively regarding instruction-acquisition situation and it has encouraged them in building self-confidence in solving physics problems and ensured positive attitude as evident in this study. This finding conforms to Knowles and Kerkman (2007) who declared a situation of no significant difference between male and female pupils that were exposed to Gagne's Learning Hierarchy strategy in their mean attitude score in physics. The current finding contradicts Craker (2006) who finds a significant difference concerning the mean attitude scores of students exposed to Gagne's Learning Hierarchy strategy in favour of the male students in science. The current investigation also contradicts the views of Moore and Stanley (2010) who reported that females in the experimental group (Gagne's Learning Hierarchy) significantly performed better than their male counterparts in science. Another likely reason for this discovery of no significant difference in male and female physics students should be as a result of the collaborative learning opportunity provided by Gagne's Learning Hierarchy strategy

Conclusions

The discoveries of this investigation has exposed that Gagne's Learning Hierarchy strategy as described in this study can be used to resolve key problems involving male and female students in instructing science subjects. Owing to the fact that it has viable empirical support and its ability to facilitate students effective leaning and organized knowledge content in a meaningful way, as well as its ability to make knowledge acquired to be long lasting among the learners without sex bias makes it an appropriate alternative among other instructional strategies for instructing science. This study has revealed that physics contents taught using Gagne's Learning Hierarchy results in better understanding and retaining science concepts among male and female physics students while eliminating biasness. The form of teacher-student interactions during teaching and learning has positive effects on the learners without been sex biased. The notable purpose of teacher-student interactions during Gagne's learning hierarchy is to ensure active students participation that should result in promoting critical thinking and problem solving skills among physics learners.

Additional research into Gagne's Learning Hierarchy could help science educators to understand the following better: (i) the impact of Gagne's Learning Hierarchy and location on students' performance in physics. (ii) Gagne's Learning Hierarchy strategy and achievements as correlates of attitude in physics. (iii) what is the influence teachers attitudes toward the implementation Gagne's Learning Hierarchy strategy.

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